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Inhalant use and suicidality among incarcerated youth

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Abstract

Studies consistently indicate that inhalant use is associated with increased mental health problems in adolescents, but few investigations have focused on the potential relationship of inhalant use to suicidality (ideation or attempt). This study examined how different levels of volatile solvent use relate to suicidal ideation and attempted suicide among 723 incarcerated youth (mean age = 15.5, S.D. = 1.2; 87% male) in Missouri, and whether any associations between solvent use and suicidality differ by gender. In bivariate analyses, severity of inhalant use was positively associated with histories of suicidal ideation and suicide attempt for both boys and girls. In multivariate analyses, inhalant use disorders remained significantly associated with suicidal ideation and suicide attempt histories even after adjusting for general level of psychiatric symptoms, prior trauma, other substance use, gender, and additional potential confounders. Inhalant use without abuse or dependence also significantly related to suicidal ideation in multivariate analyses, but an interaction between gender and inhalant use signified this relationship was stronger for girls. Inhalant use disorders in incarcerated youth, as well as inhalant use without abuse or dependence (particularly in girls), may signal elevated suicide risk. Suicide risk assessments should, therefore, include questions about inhalation of volatile solvents such as paint, gasoline, and household cleaners.

Keywords

Inhalants; Volatile solvents; Attempted suicide; Suicidal ideation; Juvenile justice

1. Introduction

Inhalant use among young people is an important, if under recognized, public health problem. An estimated 9–20% of adolescents have engaged in “huffing,” “sniffing” or “bagging” inhalants, such as gasoline, glue, shoe polish, and correction fluid (Garofalo et al., 1999;Johnston et al., 2006;Wu et al., 2004). Inhalants are widely available and easily accessible to youth, yet they can cause brain damage, heart problems, liver toxicity, acute renal failure, and death (Ridenour, 2005). Other deleterious behaviors in adolescence associated with inhalant use include delinquency, weapon carrying, and polysubstance use (Fleschler et al., 2002;Howard and Jenson, 1999;Sakai et al., 2004;Wu et al., 2004).

Of the possible correlates of inhalant use, increased risk for suicide is among the gravest. Suicide is the third leading cause of death among young people in the United States (Centers for Disease Control and Prevention [CDC], 2006). An estimated 8.5% of youth in the general population reported making a suicide attempt within the prior year (CDC, 2004), yet the proportion appears to be far higher among youth who use inhalants. For example, 21.9% of

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inhalant users in a study of Massachusetts high school students reported a suicide attempt in the previous year, compared to 6.8% of non-users in that study (Garofalo et al., 1999). In general, studies indicate that youth with prior suicidality are more likely to report inhalant use (Fleschler et al., 2002;Howard and Jenson, 1999) than nonsuicidal youth and that inhalant use relates to increased reports of suicidal ideation (Best et al., 2004) and suicide attempts (Kelly et al., 2002;Kelly et al., 2004;Sakai et al., 2004). A rare prospective study of inhalant use and suicidality found that youth who used inhalants before age 16 were almost two times more likely, relative to non-users, to later attempt suicide, even when controlling for potential confounders (Wilcox and Anthony, 2004). However, studies investigating inhalants and suicidality have been limited by various factors, including failure to apply diagnostic criteria for inhalant use disorders and over reliance on univariate analyses and single-item indicators of suicidal thoughts, suicide attempt, or inhalant use.

Few studies have examined whether the link between inhalant use and suicidality applies equally to boys and girls. Wilcox and Anthony (2004) found that girls who used inhalants before age 16 were two times more likely than female non-users to subsequently attempt suicide, yet inhalant use did not predict a suicide attempt for boys. Conversely, in a study of Inuit youth, boys who had inhaled volatile solvents were about four times more likely than male non-users to report a prior suicide attempt, but a similar relationship was not found for girls (Kirmayer et al., 1996). Gender differences consistently characterize suicidal behavior, with more girls than boys reporting a suicide attempt but more boys than girls dying by suicide (Evans et al., 2004;CDC, 2006). It is not clear whether more boys than girls use inhalants. In a study of 21,906 adolescents in Illinois, boys were significantly more likely than girls to report inhalant use, but the prevalence rates for boys (16.0%) and girls (12.6%) were not dramatically disparate (Mackesy-Amiti and Fendrich, 2000). In the 2005 Monitoring the Future Study, which surveyed 49,347 adolescents, higher proportions of girls than boys in the 8th (14.5% versus 11.6%) and 10th (19.1% versus 14.9%) grades reported lifetime inhalant use; however, 12th grade girls reported lower rates than boys (9.3% versus 13.7%) (Johnston et al., 2006). Conversely, boys and girls reported the same 12-month rate (9%) of inhalant use in an analysis of two years of data from 36,859 youth participating in the National Household Survey on Drug Abuse (Wu et al., 2004).

A keener understanding of the relationship between inhalant use, including abuse or dependence, and suicidality could aid clinicians in identifying risk factors both for suicidal behavior and inhalant use, in conducting more sensitive suicide risk assessments, and in planning treatment. Consequently, this study investigated the independent relationships between suicide ideation and attempts and different levels of inhalant use. The study attempted to avoid some limitations of previous studies by using multivariate analyses, *DSM-IV* criteria for inhalant abuse and dependence, and multiple indicators of suicidal ideation. The study sample of incarcerated youth enabled a focus on young people with particularly high needs for help because of their elevated rates of inhalant and other types of substance use (Potter and Jenson, 2003), suicidal thoughts and attempts (Abrantes et al., 2005), and mental illness (Teplin et al., 2002).

We hypothesized that (1) the risk for prior suicidal ideation and one or more lifetime suicide attempts would increase in concert with severity of inhalant use and (2) the relationship between inhalant use and suicidality would remain statistically significant and clinically important after adjusting for well-known correlates of suicidality, such as gender, other drug use, mental health symptoms, and trauma history. We also investigated whether relationships between inhalant use and suicidality differed by gender in this sample of incarcerated youth.

2. Methods

2.1. Sample and procedures

Study participants were drawn from residential rehabilitation services of the Missouri Division of Youth Services (DYS) in 2003. The study recruited all residents (N = 740) at each participating juvenile correctional facility. Ten youth were on furlough at the time of interviews and two youth were transferred to another facility before they could be interviewed. Of the remaining 728 youth available, all agreed to participate. However, four interviews were discontinued due to illness and one participant chose to stop his interview. The 723 youth who completed the interview comprised 97.7% of all residents of DYS facilities at the time of data collection, 99.3% of all residents actually available for interviewing, and 55.0% of all youth committed to DYS that year.

Interviewers completed an intensive 1-day training session, and all interviews occurred over a 3-month period. Interviews were conducted in large rooms with private areas where confidential interviews could be conducted. Youth received $10.00 for their participation.

This study was approved by DYS, the principal investigator's University Institutional Review Board, and the federal Office of Human Research Protection. A Certificate of Confidentiality was also granted by the National Institute on Drug Abuse. Analysis of these data was approved by the first author's University Institutional Review Board.

2.2. Measurements

2.2.1. Demographic characteristics—Youth were asked to give their age and to identify their race or ethnicity. Interviewers also asked what type of area the youth lived in prior to entering custody: urban city, suburban area near a city, small town, or rural or country area. For this study, responses were dichotomized as urban/suburban or rural/small town.

2.2.2. Offense and incarceration history—To assess length of time in custody, participants were asked, "How many months have you been in DYS [Division of Youth Services] custody?" Due to confidentiality arrangements associated with IRB approval of the survey, this information was not verified with administrative data. Participants also provided their age at their first criminal offense.

2.2.3. Inhalants—Participants were asked, "Have you ever inhaled/huffed [inhalant] through your nose or mouth *in an effort to get high*?" for 35 types of volatile solvents. Solvents assessed in the study were paint thinner, spray paint, liquid paint, paint remover, other paint-related substance, airplane or model glue, rubber cement, balsa wood cement, other glues or cements, toluene, shoe shine, dry cleaning fluid, spot remover, degreasing agents, gum remover, gun cleaners, floor polisher, stainless steel cleaner, other cleaning agent, octane booster, kerosene, gasoline, antifreeze, carburetor cleaners, auto brake products, permanent markers, dry erase markers, paint pens, nail polish, nail polish remover, acetone, correction fluid, mothballs, waxes, and lighter fluid.

DSM-IV diagnostic criteria for inhalant abuse and inhalant dependence apply only to volatile solvent use. Misuse of other types of inhalants, such as nitrous oxide or the nitrates, falls under "Other (or Unknown) Substance-Related Disorder," to reflect their "different modes of action and profiles of associated problems" (APA, 2000, p. 247). Thus, inhalants in this study are restricted to volatile solvents, so-called because they are vaporous at room temperature.

Respondents were classified into one of three groups on the basis of their self-reported lifetime histories of solvent inhalation: (1) no use, (2) inhalant use but no abuse or dependence, and (3) inhalant abuse or dependence. To assign a diagnosis of abuse or dependence, the study included

questions drawn from the Diagnostic Interview Schedule (Robins et al., 1995) assessing *DSM-IV* criteria (APA, 2000) for inhalant use disorders. To assess inhalant dependence, participants were asked whether they had (1) needed to increase the amount they used over time to achieve the same effect, (2) used inhalants longer than they intended, (3) wished or tried to cut down on their use of inhalants but could not, (4) spent a great deal of time over at least a 1-month period obtaining or using inhalants, (5) given up or reduced important activities in order to get or use inhalants, or (6) continued using inhalants despite experiencing health or psychological problems that they knew were caused by their inhalant use. Participants who reported experiencing at least three symptoms of dependence within the same 12-month period received a diagnosis of inhalant dependence. Withdrawal symptoms were not assessed because the *DSM-IV* states, "Inhalant dependence includes neither a characteristic withdrawal syndrome nor evidence of inhalant use to relieve or avoid withdrawal symptoms" (p. 258).

To assess inhalant abuse, youth who had used volatile solvents were asked if inhalant use had ever (1) prevented them from taking care of children or doing household chores, (2) led them to miss work, lose a promotion or raise, or get fired, (3) caused them to miss school, do poorly on tests or homework, or be suspended or expelled, (4) increased their chances of getting hurt, (5) resulted in being stopped, arrested, or taken for treatment by police, or (6) caused fights between them and other people. Participants who endorsed one or more of these items were further asked if the consequence(s) occurred more than once in a 12-month period and if inhalant use continued despite such problems. A diagnosis of inhalant abuse was assigned to youth who reported at least one of the above problems, experienced multiple occurrences of such problems in the same year, continued inhalant use despite problems, and did not meet lifetime criteria for inhalant dependence.

2.2.4. Suicidality—To assess lifetime suicidal ideation, this study used the five questions constituting the suicidal ideation subscale of the massachusetts youth screening inventory (MAYSI-2) (Grisso et al., 2001). These items assessed whether, at any time in his or her life, the youth had (1) ever wished to be dead, (2) felt that life was not worth living, (3) wanted to hurt himself or herself, (4) felt like killing himself or herself, and (5) given up hope on life. The *yes* responses were summed to create a single score for suicidal ideation with a range from 0 to 5 (alpha coefficient = .90).

To assess a history of attempted suicide, youth were asked a *yes*/*no* question, "Have you ever tried to commit suicide?" Attempt status was not added to the suicidal ideation scale for several reasons. One, adding a single indicator for attempt to a scale with five indicators for ideation would weight the constructs differentially. Two, suicidal ideation and suicide attempts are recognized as different, although overlapping, constructs (e.g., Linehan, 1986). For example, in this study, 4.9% of youth (n = 9) reporting a suicide attempt endorsed none of the ideation items, and an additional 6.5% (n = 12) scored only 1 or 2 on the ideation index.

2.2.5. Other substance use—Interviewers asked youth about lifetime use of alcohol. Those who endorsed any alcohol use were asked how many days in their life they had drunk beer, wine or other liquor. Responses were categorized as none, low use (1–10 days), medium use (11–99 days), and high use (>100 days).

Participants also were asked about the lifetime use of 15 types of other substances, besides inhalants and alcohol, for non-medical reasons: heroin, other opiates, cocaine, barbiturates, tranquilizers, amphetamines, marijuana, hallucinogens (e.g., "acid"), ecstasy (i.e., MDMA), GHB, ketamine, PCP, cough syrup, prescription drugs, and steroids. A scale was created summing the *yes* responses for these questions (alpha coefficient = .84).

2.2.6. Psychiatric symptoms—The brief symptom inventory (BSI) (Derogatis, 1993) assessed psychiatric symptoms experienced within the prior week. The instrument includes 53 items related to depression, anxiety, and other mental health problems. Each item is rated on a 5-point scale (0, *Not at all* to 4, *Extremely*). This study used the scale's general severity index (GSI), a weighted frequency score based on the sum of ratings assigned to each symptom. The BSI is a reliable and valid measure of current psychiatric distress (Derogatis and Savitz, 2000;Kellett et al., 2003). The reliability of the GSI in the present study was excellent (alpha coefficient = .96).

2.2.7. Trauma—Prior traumatic experiences were assessed with the Massachusetts youth screening inventory traumatic experience subscale. Youth were asked five *yes*/*no* questions about traumatic experiences (e.g., being severely injured or in danger of severe injury or death), and *yes* responses were summed (range, 0–5). Reliability of the index in the present study was adequate (alpha coefficient = .77 for girls and 68 for boys).

2.3. Analyses

With the exception of the suicidal ideation variable, differences in means were assessed with *t*-tests and one-way analysis of variance. Because the distribution of data for suicidal ideation dramatically departed from normality, non-parametric tests (Wilcoxon rank sum and Kruskal–Wallis tests) were employed to test group differences in ideation scores. Chi-square tests of independence tested for differences in proportions. Adjustments for multiple comparisons were made using Bonferonni's correction for each group of bivariate comparisons.

In bivariate and multivariate regression analyses, suicidal ideation and suicide attempt were dependent variables in separate models. Multiple linear regression analyzed correlates of suicidal ideation; regression diagnostics showed that the residuals approximated a normal distribution. The models using suicide attempt as the dependent variable employed logistic regression. The independent variables for both multivariate models were inhalant use with abuse/dependence and inhalant use only. Each was categorically (i.e., "dummy") coded, and no use served as the referent group; abuse and dependence were combined due to low numbers of youth who met the abuse criteria. Control variables included age, gender, prior residential location type, number and frequency of substances used besides inhalants, psychiatric symptoms, and trauma history. Length of time in custody, age at first offense, and alcohol use were omitted from multivariate analyses to improve parsimony and avoid collinearity with other variables (e.g., age and number of drugs used). For each multivariate regression, variables entered the model simultaneously.

To assess gender differences in the relationship between solvent use and suicidality, bivariate analyses were conducted separately for the entire sample, boys, and girls. In multivariate analyses, interaction terms were created for gender and solvent use without abuse or dependence, as well as for gender and solvent abuse or dependence; an interaction term was retained in the final model only if significant. Separate multivariate models for each gender were not run because the low number of girls would have limited the model to very few independent variables and precluded comparability with the model for boys.

3. Results

3.1. Sample characteristics

The sample, as shown in Table 1, was mostly male and averaged 15.5 years of age. Boys and girls differed on many characteristics. Girls had markedly higher levels of prior suicidal ideation and reported significantly more alcohol use, other substance use besides alcohol and inhalants, and psychiatric symptoms. Boys and girls also differed by race and ethnicity, with

higher proportions of Black boys and White girls. Age, urban or rural residence, and trauma history did not distinguish boys and girls. Although boys and girls reported similar mean lengths of incarceration, boys reported having committed their first criminal offense about 1 year earlier, on average, than girls.

One-third (33.1%, $n = 239$) of youth reported that they had inhaled volatile solvents. Among youth who reported any solvent use, 62.4% ($n = 149$) did not fulfill diagnostic criteria for inhalant abuse or dependence. The prevalence of lifetime inhalant use did not differ significantly by gender.

One in four youth (25.5%, $n = 184$) indicated that they had attempted suicide. More than half (58.3%) of youth endorsed at least one of the five questions pertaining to suicide-related ideation. Of the 420 youth who did endorse at least one item, the average number of items endorsed was 3.4 (S.D. = 1.6). Girls reported significantly higher levels of suicidal ideation and prevalence of suicide attempts than boys. Girls' median ideation score was 4, compared to 1 for boys ($p < .001$). The proportion of girls (51.1%) reporting a prior attempt more than doubled that of boys (21.7%) ($p < .001$).

3.2. Inhalant use and suicidality

The degree of past suicidal ideation and prevalence of suicide attempt history increased monotonically with severity of volatile solvent use in bivariate analyses for the entire sample and for boys and girls separately (Table 2). To ascertain whether this relationship reflected the role of substance use generally or solvent use uniquely, suicidality variables were regressed, in separate models, on the measures for alcohol use and for other substance use, and the models were then adjusted for inhalant abuse/dependence and inhalant use. The inhalant use variables remained statistically significant and weakened the relationship that alcohol use and other substance use had bivariately with each suicidality dependent variable (not shown). For example, other substance use was statistically significant ($b = 0.27$, $p < .001$) and explained 7.4% of the variance in the regression model with suicidal ideation as the dependent variable. When the inhalant use variables were entered into the model, the amount of explained variance increased to 15.2%, the coefficient decreased for other substance use ($b = 0.12$, $p < .01$), and results were statistically significant for both inhalant use ($b = 0.16$, $p < .001$) and inhalant abuse/dependence ($b = 0.31$, $p < .001$). Alcohol use, though significantly related to both suicidal ideation and suicide attempt when considered alone, lost statistical significance when the inhalant variables entered the models (not shown).

The positive relationship between solvent use and suicidal ideation remained statistically significant in multivariate analyses controlling for potential confounders (Table 3), whether or not the youth merited a *DSM-IV* diagnosis for inhalant abuse or dependence; however, a significant gender-by-use interaction term indicated that solvent use without a diagnosis of abuse or dependence was more strongly associated with ideation scores for girls than boys. The linear regression model explained 36% of the variance in suicidal ideation scores. In the logistic regression model, solvent use that did not meet the diagnostic threshold for abuse or dependence was not significantly related to suicide attempt. In contrast, the likelihood of reporting a suicide attempt was slightly more than five times higher among youth with an inhalant use disorder, compared to youth with no solvent use. No interaction terms were significant in the logistic regression model, and therefore they were dropped to avoid distorting results for the main effects. The logistic regression model correctly classified 81.46% of study participants.

4. Discussion

This study is the first to examine inhalant use at three levels – none, use only, or abuse/dependence – and its relationship with suicidal ideation and attempts in incarcerated youth. The study's major findings concern the very strong relationship between inhalant use disorders and suicidality (ideation and attempt) for boys and girls alike in juvenile correctional facilities. Relative to youth who did not report inhalant use, youth whose inhalant use met *DSM-IV* criteria for abuse or dependence reported a higher degree of lifetime suicidal ideation and were more likely to report a prior suicide attempt, even when controlling for number of other substances used, psychiatric symptoms, trauma, gender, and other covariates. Inhalant use that did not meet criteria for abuse or dependence also positively related to severity of prior ideation, but this relationship was stronger for girls than boys. Inhalant use without abuse or dependence was not associated with suicide attempt history when controlling for confounders. The discrepant findings for non-diagnosable inhalant use may owe to substantive differences in ideation and attempts or, instead, to differences in measurement; the ideation variable, measured continuously on a scale of 0–5, simply had more statistical power than the dichotomously measured attempt variable to detect systematic relationships.

The reasons for the link between suicidality and solvent use are unknown. One possible explanation is that the solvent use-suicidality association is simply one exemplar of a more general relationship between psychoactive substance use, particularly CNS depressant use, and suicidality. Numerous studies have documented a link between suicide risk and alcohol (Cherpitel et al., 2004) and other drug (Borges et al., 2000) use. Yet the current study controlled for the other substance use in both bivariate and multivariate regressions. Inhalant abuse and dependence consistently remained significantly associated with suicidal ideation and suicide attempt, as did inhalant use with suicidal ideation. Meanwhile, alcohol use lost statistical significance when regression models controlled for inhalant use, and the relationship of other substance use with suicidality either weakened or lost statistical significance altogether. These analyses indicate that inhalant use is associated with lifetime suicidality independently of other substance use, reducing the possibility that it serves merely as a proxy for substance use, itself a marker of suicide risk.

Another possible explanation for the link between solvent use and suicidality is that psychiatric problems give rise to both problems. However, the relationship between solvent use disorders and suicidality persisted even when controlling for current psychiatric symptoms. As happened in analyses with other substance use, multivariate analyses indicate that solvent use may uniquely contribute, above and beyond any mutual relationship with psychopathology, to a history of suicidal thoughts or suicide attempts. At the same time, the study's assessment of current psychiatric symptoms may have failed to capture the potential impact of prior emotional problems that have abated with time or treatment. The assessment of psychiatric symptoms also did not allow for diagnosis of psychiatric illness.

The association of inhalant use with suicidality may be explained by one or more intervening variables not measured in the current study. Research has shown that solvent users are more likely to live in poverty, experience social isolation, and have family histories of serious depression, alcoholism, and antisocial personality disorder (Wu and Howard, 2007;Wu and Ringwalt, 2006). Thus, solvent use may serve as a proxy for factors that themselves heighten suicide risk and that were not measured here. Additionally, impulsivity may mediate the relationship between inhalant misuse and suicidality. Inhalant use is considered an indicator of greater impulsivity in adolescents (Sakai et al., 2006), and impulsivity also is associated with nonfatal suicidal behavior in adolescents and young adults; in one study, 24% of people, aged 13–34, reported that they had contemplated suicide for fewer than 5 min before they made a nearly lethal suicide attempt (Simon et al., 2002).

Finally, although an unknown mediator may exist, the relationship of inhalant use and suicidality could be causal. The cross-sectional nature of the current study precludes such a determination, but several authors have noted that volatile solvents, like alcohol, are central nervous system depressants (Evans and Balster, 1991;Ridenour, 2005) and potentially disinhibiting of violent self-injury. Solvent use also is thought to affect serotonin transporters (Lopreato et al., 2003), and low levels of serotonin are associated with depression and suicide (e.g., Hsiung et al., 2003;Mann et al., 2000). Morrow et al. (2001) studied workers exposed to solvents in occupational settings and found that they presented with anxiety disorders at markedly higher rates than non-exposed controls (58% versus 7%, $p < .001$). It is possible, though only speculative at this point, that inhalant use and emotional distress give rise to a vicious cycle, each causing the other to increase, eventually escalating to suicidal despair. Unfortunately, this study's limited data on psychiatric symptoms preclude an investigation specifically of depression as a possible mediating variable.

Despite a gender interaction in the relationship between non-diagnosable solvent use and suicidal ideation history, the overall results were largely similar for boys and girls. The interaction indicates that solvent use without abuse or dependence relates more strongly to ideation history for girls than boys. This difference is illustrated in Table 2, which shows that the median ideation score for female solvent users (without abuse or dependence) increased three points, compared to a two-point increase among comparable boys. Otherwise, prevalence rates of solvent use and solvent use disorder were generally similar, and all types of solvent use related bivariately to prior suicidal ideation or attempts for both boys and girls. Higher proportions of girls than boys met criteria for abuse or dependence, but these differences were not significant. These results contrast with those of other studies that have found statistically significant gender differences (Johnston et al., 2006;Kirmayer et al., 1996;Mackesy-Amiti and Fendrich, 2000).

The gender commonalities and differences found in this study may not be generalizable to non-incarcerated youth, particularly girls. Research indicates that girls in juvenile corrections tend to present with more psychopathology and behavioral problems than boys (Abram et al., 2003;Wasserman et al., 2005), perhaps because delinquency occurs less frequently in girls and consequently signifies more severe psychopathology, relative to boys (Eme, 1992;McCabe et al., 2002). In this study, girls reported higher rates of drug use (besides solvents), alcohol problems, psychiatric symptoms, suicidal ideation, and suicide attempts than boys. Girls in correctional facilities also may be more disturbed because of higher rates of abuse, family violence, and other trauma (Alemagno et al., 2006), but reports of trauma in this sample did not differ significantly by gender. In any case, more research is needed in both incarcerated and non-incarcerated samples to determine whether solvent use and solvent abuse or dependence signify different levels of suicide risk for boys and girls, as such differences could have implications for prevention, assessment and treatment of solvent misuse as well as suicidality.

Although not central to the study's research questions, other findings emerged that deserve mention. Consistent with research in other populations, psychiatric symptoms, trauma history, and female gender also positively related to both suicidal ideation and suicide attempts. Additionally, the likelihood of suicidal ideation and suicide attempt both differed according to race and ethnicity. Black youth and Hispanic youth were less likely to have attempted suicide than White participants (Table 3); both groups also had lower odds of prior suicidal ideation than White youth, but the difference was statistically significant only for Black study participants. These disparities commonly occur in other populations as well, with the exception of Hispanic female adolescents, who tend to have higher rates of suicide attempt than White adolescents (CDC, 2004). In this study, sub-analyses showed that a smaller proportion of Hispanic girls, relative to White girls, reported a prior attempt (16.7% versus 27.8%) but the

difference did not attain statistical significance ($\chi^2 = 1.4$, $p < .25$). White youth had lower rates of suicidal ideation and suicide attempt than youth of other races and ethnicities besides Black and Hispanic, but the meaning of this finding is difficult to interpret due to the heterogeneity of the group for other races.

Several characteristics of the study limit the interpretation of its findings. Most notably, the cross-sectional data do not convey whether inhalant use or suicidality came first. Such knowledge would be especially meaningful in understanding the sequelae of both suicidality and solvent use. It is quite possible that the relationship is bidirectional, given that suicidal youth may use inhalants to escape their suffering and that inhalants, as central nervous system depressants (e.g., Evans and Balster, 1991), may cause further psychological symptoms. Other limitations include the single-item measure of suicide attempt, the assessment only of current psychiatric symptoms, and the limited measurements of other types of drug use and of prior trauma; the data lacked diagnostic criteria for substance abuse and dependence for all substances besides inhalants. Likewise, some of the criteria for inhalant abuse used in this study, although consistent with diagnostic criteria in the *DSM-IV*, may be problematic when evaluating adolescents because they address problems functioning at a job or with one's children.

Also, because the study includes only incarcerated adolescents, the results may not apply to youth in general. Incarcerated adolescents overwhelmingly tend to have more severe psychopathology than their counterparts in the community (e.g., Teplin et al., 2002), so a study of exclusively incarcerated youth may exaggerate or otherwise distort the association between inhalants and suicidality. However, it is notable that studies using community or school-based samples of adolescents have consistently demonstrated a relationship between inhalant use and suicidal thoughts (Best et al., 2004) or suicide attempts (Garofalo et al., 1999;Wilcox and Anthony, 2004). Inhalant use and suicidality have remained associated in other specialized samples, including Inuit youth (Kirmayer et al., 1998), adolescents with a substance use disorder (Kelly et al., 2004) or behavioral problems (Sakai et al., 2004), students in an alternative high school (Fleschler et al., 2002), and youth on criminal probation (Howard and Jenson, 1999). The consistent relationship of inhalant use and suicidality, regardless of setting, suggests that the relationship between solvents and suicidality is not unique to incarcerated youth.

The findings carry several important implications for research and practice. The persistent relationship between suicidality and solvent use, particularly that meriting a diagnosis of abuse or dependence, raises further research questions about the temporal sequence of solvent use and suicidality, as well as the specific physiological, psychological, and environmental mechanisms through which they relate to each other. Further research would benefit from a longitudinal design with a community sample of youth, ideally, or from including age-of-onset indicators for solvent use, suicidal ideation, and attempted suicide. A major implication for practice concerns the need, when doing assessments of either substance use or suicide risk, to inquire specifically about solvent use and suicidality. For both boys and girls, solvent use and suicidality may each constitute a red flag for the other, and their comorbidity needs to be explored when assessing youth and planning for their safety.

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Table 1

Sample description and comparisons by gender characteristic

	Total (*N* = 723)	Boys (*n* = 629)	Girls (*n* = 94)	Test statistic[a]	*p*[b]
Age (*M*, S.D.)	15.5 (1.2)	15.5 (1.3)	15.4 (1.1)	*t*, −0.84	.400
Race (%)					
White	55.3	53.1	70.2	χ^2, 12.7	.005
Black	32.9	35.3	17.0		
Hispanic	3.9	3.8	4.3		
Other	7.8	7.6	8.5		
Prior location (%)					
Urban/suburban	53.0	52.8	54.2	χ^2, 0.07	.790
Rural/small town	47.0	47.2	45.7		
Age at first offense (*M*, S.D.)	10.5 (2.9)	10.3 (2.9)	11.6 (2.7)	*t*, 3.8	<.001
Months in custody (*M*, S.D.)	7.5 (8.5)	7.6 (8.5)	6.6 (8.6)	*t*, −1.1	.282
Inhalant use (%)					
None	67.0	67.4	63.8	χ^2, 2.2	.540
Use only	20.6	20.8	19.2		
Abuse, no dependence	1.8	1.8	2.1		
Dependence	10.7	10.0	14.9		
Suicidal ideation (median)[c]	1	1	4	*z*, 5.4	<.001
Suicide attempt (%)	25.5	21.7	51.1	χ^2, 37.2	<.001
Alcohol use (%)					
None	13.1	13.8	8.5	*F*, 9.9	.019
Low (1–10 days)	27.3	28.5	19.2		
Medium (11–99 days)	28.4	26.6	40.4		
High (≥100 days)	31.3	31.2	31.9		
Other substances used[d] (*M*, S.D.)	3.4 (3.0)	3.3 (3.0)	4.0 (3.3)	*t*, 2.3	.021
GSI total[e] (*M*, S.D.)	43.8 (34.8)	42.4 (34.2)	53.0 (37.5)	*t*, 2.8	.006
Trauma[f]	3.0 (1.6)	3.1 (1.7)	2.9 (1.6)	*t*, 1.0	.343

[a] Bivariate comparisons by gender. Wilcoxin ranked sum tests reported for suicidal ideation scores.

[b] Using Bonferonni's correction for multiple comparisons, the threshold for statistical significance in this group of comparisons is .004 (.05/12).

[c] Lifetime suicidal ideation measured on scale of 0–5 (MAYSI-2 subscale).

[d] Sum 15 different types of substances used.

[e] General severity index scores ranged from 0 to 172.

[f] Trauma measured on scale of 0–5 (MAYSI-2 subscale).

Table 2

Bivariate relationship of solvent use and history of suicide ideation or attempt

	No use	Use only	Abuse or dependence	χ^{2a}	p^b
Ideation (median)[c]					
All	0	2	5	93.7	<.001
Boys	0	2	5	72.3	<.001
Girls	2	5	5	21.9	<.001
Attempt (%)[d]					
All	17.0	30.2	63.3	88.1	<.001
Boys	13.7	26.0	59.5	79.5	<.001
Girls	40.0	61.1	81.3	9.5	.009

[a] For continuously measured ideation variable, Pearson's chi-square reported for nonparametric Kruskal–Wallis test.

[b] Using Bonferonni's correction for multiple comparisons, the threshold for statistical significance in this group of comparisons is .008 (.05/6).

[c] Range 0–5.

[d] Measured dichotomously. Proportion of attempters reported for each level of inhalant use.

Table 3

Regression models predicting severity of prior suicidal ideation and history of suicide[a]

Variable	Ideation (range, 0–5)[b]		Attempt (yes/no)[c]	
	b	95% CI	Odds ratio	95% CI
Inhalant (solvent) use				
None (ref.)	–	–	–	–
Use only	1.36**	0.47 to 2.24	1.41	0.84–2.37
Abuse/dependence	1.46**	0.52 to 2.40	5.13***	2.73–9.65
Male gender	−0.61***	−1.06 to −0.15	3.79***	2.24–6.42
Gender × use only	−1.04*	−1.97 to −0.11	N/A	N/A
Race				
White (Ref.)	–	–	–	–
Black	−0.83***	−1.16 to −0.51	0.41**	0.23–0.75
Hispanic	−0.60	−1.24 to 0.04	0.24*	0.08–0.74
Other	0.52*	0.06 to 0.98	1.51	0.77–2.94
Psychiatric symptoms	0.02***	0.02 to 0.03	1.02***	1.01–1.03
Trauma	0.10*	0.01 to 0.19	1.20*	1.03–1.39

[a] Only predictors with statistical significance in at least one model are shown in table. Non-significant variables in both models were age, prior residence (urban/rural) and number of drugs used besides volatile solvents. The linear regression model also contained an interaction term for gender and solvent abuse/dependence.

[b] Multiple linear regression; model $F(13, 697) = 32.1$, $p < .001$, adjusted $R^2 = .36$.

[c] Logistic regression; model $\chi^2(11) = 199.3$, $p < .001$, pseudo-$R^2 = .25$.

* $p < .05$.

** $p < .01$.

*** $p < .001$.